A Bayesian age-depth modelling of a full Pliocene-Quaternary tephrochronological framework for the Northwest Pacific Deep Sea cores

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Geochemically fingerprinted widespread tephra layers are excellent marker horizons that can serve as isochrons over vast areas. Deep sea sediments in the areas close to the volcanoes provide a continuous tephra record over millions of years. This study considers deep sea cores taken at sites 882 and 884 during the Ocean Drilling Program (ODP) Leg 145 of the R/V JOIDES Resolution in 1992 (Rea et al., 1993), and a giant piston core MD01-2416 obtained during the WEPAMA cruise of the R/V Marion Dufresne in 2001 in the frame of the IMAGES program (Holbourn et al., 2002), all located on the Detroit Seamount in the NW Pacific.

Geochemical correlations of tephra layers among the three cores have permitted the construction of the summary tephra sequence that includes 109 individual layers deposited over the last 6 My. This permits us to combine individual age-depth models for each site into the integral and consistent age model. Initial biostratigraphical age models for sites 881 and 884 as well as the downcore magnetic inclination data were obtained by the ODP Leg 145 team. After that, some astrochronological age models were published, however, none of the cores were included in ^{18}O benthic stack LR04 (Lisiecki and Raymo, 2005).

The main high-resolution age models for these sites are:

- Site ODP 882 - XRF correlations to Antarctic EPICA Dome C age model (EDC3) for the last 800 ky (Jaccard et al., 2010); astronomical tuning of gamma-ray attenuation porous evaluation variations for the last 4 My (Tiedemann and Haug, 1995); magnetic reversals correlations of the bottom 100m of the core.

- Site MD01-2416 - ^{14}C dates for the interval between 10 and 20 ka BP (Sarnthein et al., 2015); ^{18}O correlations to the marine isotope stages for the last 1,3 My (Gebhardt et al., 2008).

- Site ODP 884 -^{14}C dates and ^{18}O correlations to the marine isotope stages for the last 250 ky (VanLaningham et al., 2009); a continuous record of distinct geomagnetic reversals, which were correlated to geomagnetic polarity time scale of Cande and Kent (1992).

Accuracy of these models is not uniform. As shown by Lisiecki and Raymo (2005), ^{18}O records of deep sea sediments converge within 4 ky in the late Quaternary to 30 kyrs in Miocene, and for the EDC3 the age accuracy comprises 3 ky (Dreyfus et al., 2007, Jouzel et al., 2007). Therefore, we need to estimate ages of the events, taking into account all the individual high-resolution age models. As the known data include some prior age estimations and empirical observations of tephra correlations, the most suitable approach is a Bayesian statistics. We have constructed an age model, where each date was treated as a boundary of uniform deposition sequence with known depth, age and its uncertainty, while tephra layers linked these sequences. The model was processed in OxCal 4.3 software (Bronk Ramsey, 2009), which is a powerful tool for Bayesian age modelling suitable not only for ^{14}C ages. As a result, we have obtained an integrated and consistent age model, incorporating all the tephras found in the cores with accuracy estimations varying from 500 yrs after LGM to some 25 ky in early Pliocene. The real accuracy may be slightly lower, as we infer uniform deposition rate between the tie points.

This study provides age estimates for the tephrochronological framework of the entire Pleistocene-Quaternary of NW Pacific. Tephras found in these cores some 700 km off the coast correspond to VEI 5 or larger eruptions, so they could serve as isochrons in the marine, terrestrial and ice records of the region, providing additional age data to local chronological studies.

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